Epileptologist's Assistant: A Cost Effective Expert System

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ABSTRACT

Epileptologist's Assistant is an expert system designed to cost effectively handle routine care in an epilepsy follow up clinic. The system guides nurses in gathering patient histories and then generates progress notes and a patient information sheet. The progress note, organized in the SOAP format, is reviewed by the physician with the patient. For difficult cases the physician may modify the Assessment or Plan sections; the Subjective and Objective sections rarely need modifications.

The assertion of cost-effectiveness is based on time/motion data. Without the system a physician in our epilepsy clinic spends about 21 minutes seeing a patient. With the system the nurse spends about 14 minutes with the patient and the physician spends about 7 minutes. Two nurses and a physician handle the work load of 3 physicians. Physician time is cut by about 66%. Using the average salaries for physicians and nurses at the Department of Veterans Affairs, the cost of a clinic visit is reduced 39% by using the expert system and nurses. In addition, the progress note is more legible, it contains more information, Q/A procedures are implemented at the point of patient contact, and the data is entered into a computer system in a data field format.

INTRODUCTION

Our concept of developing expert systems with a primary goal of COST EFFECTIVE ASSISTANTS to physicians arose from our first expert system project, "Hepatologist's Assistant" [8, 9, 20, 21]. We believe this function will be a driving force in medical expert systems finally being routinely used.

While there are enumerable applications for the concept of creating assistants to experts, we have selected a system in the domain of epilepsy for several reasons: 1) The Department of Veterans Affairs (VA) was already aware of and committed to the need for specialized epileptic treatment. It established and maintains 5 Regional Epilepsy Centers. 2) Effective treatment requires attention to details and following prescribed protocols. 3) Follow up clinics are physician intensive. Much of the data is derived from the patient. 4) In addition epilepsy treatment has 'boundaries.' We do not need a system which must know all of internal medicine in order to support 'routine epileptic care.' All these reasons made this project a good model project.

Our goal is for expert systems to enable paramedical personnel to be the "best assistants the physicians ever had". Our system: 1) enables paramedical personnel to gather the necessary patient history; 2) documents the details; 3) follows prescribed protocols; 4) generates the paper work. Our system effectively handles the 'ordinary' patients. The physicians can spend more of their time taking care of the 'extra-ordinary' patients. "Epileptologist's Assistant" enables more efficient use of physician resources. However, without the physician's expert supervision our system has no function.

Our systems do not practice medicine. All the information gathered is presented to the physician, and the assessment and plans are suggestions to the physician. The physicians are free to make whatever changes are necessary. Our approach is simply building on the current practice of using nurse practitioners. Physicians are in total control; as the experts, they make and are responsible for the final decision. We desire to increase our experts' efficiency, not eliminate them. We feel this approach is realistic. Of all today's commercially successful expert systems, very few replace an expert. The rest of the successes are objectively described as 'assistants TO experts.'

The goal of developing a 'practical assistant TO the expert' is very significant. It means that to be successful we require our system to be good but not infallible. The cascade of obstacles in past medical systems is eliminated. Practicality is possible.

A major issue in end user acceptance of past systems has been that the system slowed down the work of the user [12]. The recent availability of

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graphical user interfaces and more powerful computers have largely eliminated this obstacle. Using our system is faster than using pen and paper.

METHODS

Clinic Description and Time/Motion Analysis

Our analysis is based on time/motion modeling. We treat our systems as single or multiple channel, finite input source systems with physicians or nurses being servers [1, 3, 7]. This simply means that there are one or more queues of patients waiting to see the physicians or nurses. There are always patients in the queues. Thus, the length of the physicians' and nurses' visits limit the throughput of the systems. The cost for patient consultation is a variable labor cost and does not include any fixed costs (e.g., building, utilities, etc).

For both nurses and physicians TIME starts when they take the chart from the shelf and ends when the chart is placed back on the shelf. It includes such activities as: walking to the examination room, getting the patient to the examination room, reviewing the chart, interviewing the patient, discussing the patient with others, writing a progress note and prescriptions, helping the patient out of the examination room, walking back to the chart shelf and placing it back on the shelf. We have not adjusted those costs for down time, personal time, administrative time, teaching time, research time, etc. While such considerations would make our system even more cost effective, the individual variances are great. We believe such analysis is unnecessary at this time since the simpler, more conservative model shows a large, significant dollar savings without the details.

Without Computer System The physician alone treatment process (no nurse, no expert system) is modeled, as stated above, as a single or multiple channel, finite input source system. The primary variable is the labor cost for a patient visit.

With Expert System The nurse/expert system-physician arrangement has two serving stages, a single or multiple channel in the first stage and single or multiple channel in the second, with a finite input source to each server. There are 1 or more nurses in the first serving stage and 1 or more physicians as the second serving stage. The primary variables in the evaluation of this system are: 1) the consultation cost for a patient for service by a nurse (length of time in hours or a fraction thereof multiplied by hourly cost of nurse time) and 2) the consultation cost for a patient for service by the physician (length of time in hours or a fraction thereof multiplied by hourly cost of physician time). The total variable labor cost for a patient visit is the sum of the costs of the consultations for the two stages and does not include any fixed costs for providing the consultation.

The progress note is in the form of SOAP. 'S' stands for SUBJECTIVE - what the patient tell you. The 'O' stands for OBJECTIVE - what you can observe (test results) of the patient. The 'A' stands for ASSESSMENT - what all the data means. The 'P' stands for PLAN - based on the assessment, what is going to be done.

Statistical Significance The determination of a significant reduction in the variable cost for the proposed expert system from that of the current system is based on the following:

> *Hypothesis: the mean cost of consultation for a patient visit in the proposed system is less than the mean cost of consultation for a patient in the current system.*

The hypothesis is tested by the application of Student-t test to evaluate the difference in the mean consultation costs of the two systems.

Software Design The interface was required to be intuitive, adjust to the needs of different users, and have intelligence to anticipate the users' needs.

Our approach is to build intelligence into the graphical interface. The interface must adjust to and anticipate the needs of the user. Only relevant questions should be asked. Different users of the same system must be presented the data in different formats. The user must be free to concentrate on medical care, not the technology. With such a design, the technology 'disappears.' Our interface was required to be easier than paper and pencil; paper and pencil is too difficult (as is evident from the number of inadequate progress notes). We believe the quality of an interface is a major factor in the ability of a system to be cost effective and practical.

RESULTS

Software

The current system is implemented on IBM-compatible PC's running Windows using Nexpert Object (an artificial intelligence shell by Neuron Data) and ToolBook (a graphical user interface by Asymetrix). Patient data are stored in DBase III files. The system has about 10 general screens developed in ToolBook. As necessary Nexpert can ask any of 300 possible questions directly through a generalized ToolBook interface. The number of questions asked in an interview is usually limited to 30 to 50 under the control of the approximately 200 rules in the system. The data is stored in about 20 DBase files.

An example of one of the rules is:

[IF::
Side_Effects is FALSE
and
Seizures_Control is UNACCEPTABLE
and
Patient_Willing_To_Increase_Medication is TRUE
and
Nurse_Willing_To_Increase_Medication is TRUE
THEN::
Suggest_Increasing_Medication is TRUE]

Additional rules handle cases where one or more of the IF:: conditions have a different value. The utility of a good AI shell becomes obvious when there are hundreds of rules with intermediate conclusions. The shell displays the interdependency of the rules as a network. In debugging the system the nodes turn colors indicating the status of each node. The actions of the system can be quickly traced with such tools.

Time/motion Studies

The data is summarized in Table I. When patients are seen only by physicians, it takes 21.35 minutes on the average for a clinic visit. Using a VA physician average annual salary with benefits of $134,810 ($73.27/hr), the costs is $26.07 to evaluate an epileptic. Using our system it takes a nurse 14.97 minutes. Using a VA annual average salary with benefits of $50,694 ($27.53/hr) for a nurse, the cost is $9.03 to pre-interview a patient. It then takes the physician 7.4 minutes and costs $6.87 to check the progress note with the patient. The total cost for the visit with the expert system is $15.90. (This total average cost was calculated by averaging the cost of each patient's visit: (Nurse_Time X Nurse_Salary) + (Physician_Time X Physician_salary)) With the expert system, there is a savings of $10.17 or 39%.

DISCUSSION

Conservation of Physician Time

The function of a 'time saving assistant' to an expert physician is usually ignored in discussions on medical expert system applications [i.e. 10]. But for us this was the logical place to begin [8, 9, 19, 20].

Guidance of Para-medical Personnel Nurses or other para-medical personnel, with proper training, are capable of accepting more responsibility for patient care. Both in the private and VA hospitals, nurses are being given specialized training so that they can accept this responsibility. The specific responsibility of gathering patient information is already delegated to non-physicians, e.g. to physician assistants, nurse specialists, or other trained personnel. Our VA Medical Center has a 'nurse clinic' for adjusting anti-coagulant medication. Our University Department currently runs epilepsy clinics where nurses gather much of the patient history.

Nurses can quickly learn how to ask specific questions and how to interpret the responses. What takes more time is learning "when" to ask "what" and "what does it all mean." That expertise requires more training and time to develop. In the University clinics it takes a nurse about 9 months of working with epileptic patients 5 days a week to become fully trained. In many clinics the small numbers of patients (half day a week clinic) cannot justify the expense of training personnel. Even for larger clinics, the lack of qualified personnel and the personnel turnover rate often makes such training impractical. As a result, physician time often is spent inefficiently doing tasks that could be delegated to others.

Our expert assistant makes the training of nurses to assist physicians more practical. Instead of taking months to train a nurse, training can be accomplished in hours or days. The system helps nurses determine "when" to ask "what" and provides some insight into "what it all means." Nurses need to learn only the meaning of questions and answers. They do not need to learn the complicated rules about when data is clinically relevant. There are over 300 questions in our system that could be asked of a patient. However, our system directs the nurse to ask the relevant ones for each patient, usually 30 to 50 questions. Our system allows nurses to work at a higher level of responsibility. They have more direct patient contact. In general, medical computer systems are very popular with nurses. Nurses perceive these systems as elevating their professional status [11, 12].

Report Preparation for Physician Review Physicians, known for their dislike of clerical duties [22], seem to appreciate our system's generation of progress notes, histories, recommendations, and rationales for their review. The data are arranged in a logical order to assist the physicians in reaching their decision. The system allows the physician to edit and amend the report as appropriate. The output is ready for the physician to sign and place in the chart. In addition our system does not prevent the physician from adding notes to the reports. Such notes have been identified as part of the physician's thought process [23, 24]. Our system is to assist the physician, not obstruct normal operations.

Quality Control Assurance Device

Making mistakes is inevitable and constantly striving to meet standards is difficult for everyone. Physicians are no exceptions [2, 4, 6, 15, 16, 18]. McDonald [16] found that a reminder system enabled physicians to work closer to their own standards. Our system functions as a type of 'reminder system.' The system offers suggestions for the assessment and plan,

but the final decision is always the physician's. As a result of the checks included in the system, the patient receives more individual attention, and a higher quality of overall medical care is achieved. Since neither the expert system nor the physician is perfect, the two working together can improve the performance of either working alone [5, 13, 14].

With our system each patient is evaluated three times. The first evaluation is by the expert system, the second is by the nurse, and the final is by the physician. The three evaluations function as checks on each other.

Device for Implementation of Standard Clinical Protocols Traditionally, quality control focused on avoiding human error. Standard procedures were derived, and operational systems to monitor compliance were established. Our expert assistant system fits nicely into this framework. It establishes standard procedures and provides a means of monitoring exceptions. Most significantly, established procedures are checked at the point of patient contact. Expert systems provide the tools to implement complicated rules that were too difficult to describe with paper flow charts and decision trees.

Assurance of Essential Data Collection and Documentation Recently, quality control has included an expanded function: to ensure the recording of relevant data to enable assessment of alternative treatments. Our expert assistant system is an excellent vehicle for implementing this function. It assures that data is collected in a uniform format and is available for future analysis. With our system data collection is quicker than with pen and paper.

Future Directions

Several additional studies are planned or underway. 1) We are evaluating the system with more users. 2) We are evaluating the system at several non-VA sites. 3) We are comparing the quality of progress notes from the system to hand written notes. 4) We have identified several clinical indicators for quality of care and are assessing the system's ability in improve quality of care (This study will take time since epileptics are usually seen at 6 month intervals). 5) We are extending the analysis to the cost of nurse training. 6) Currently there are few rules that use previous visit data; this type of rule will be expanded.

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TABLE I

Time and Cost of Patient Clinic Visit Without and With Expert System

	Min.	SEM	N	Cost	SEM	N
PHYSICIAN ALONE[1]	21.35	0.95	140	$26.07	$1.12	140
EXPERT SYSTEM[2]						
Nurse	14.97	0.81	27	$ 9.03	$0.49	27
Physician	7.40	0.68	27	$ 6.87	$0.63	27
Total Cost				$15.90	$0.97	27

[1] Data are from 3 physicians collected over a 6 month period. No statistical difference between physicians; groups combined.

[2] Data are from 1 physician and 1 nurse. Patients were consecutive patients in several clinics over a 2 month period. All patients were evaluated only once with the expert system.